POLICY FORMULATION IN SCIENCE AND TECHNOLOGY

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(The opinions expressed in this article are those of the authors and not necessarily of the organisation to which they belong).

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By

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POLICY FORMULATION IN SCIENCE AND TECHNOLOGY

1. INTRODUCTION

Science is traditionally recognised as an endeavour, or an intellectual activity, concerned with the search for knowledge and understanding of nature. It thrives on the innovative and creative ability of individuals who are motivated by their curiousity for understanding the physical phenomenon which they observed around them. It is therefore difficult to imagine, in the first place, how this activity could be organised and planned. Indian science was no exception to this rule, as can be seen from India's contribution to science in the early part of its history. The contributions of great scholars like Aryabhatta, Susruta, Varahamihira and Bhaskara are important landmarks in the history of Indian science. Though the work of these and other scholars in different branches of knowledge, such as astronomy, mathematics, medicine, chemical practices and alchemy, agriculture, botany, zoology, etc., views and concepts about the physical world have been developed in India, but it would be difficult to associate these developments as being part of an organised and planned activity, depicting the policy of those who ruled India in ancient times. No doubt the rulers at that time encouraged these thinkers and philosophers in their pursuit of science but whether they did so with the intention of building up an organized scientific base for the country cannot be established. The initiative for satisfying the curiousity of man rested with the individuals who were motivated by their inner zeal. The dedication of individuals gave rise to new knowledge and the scientific activity remained concentrated around these individuals. The traditionally fostered learning was confined to a select class of people who preferred to preserve it with diligence and care only in the nature of elaborate commentories. The professionalists - the artisans and the craftsmen which could have ideally thrived on generation of new knowledge and its appropriate application to their activities - remained isolated from these creative minds, perhaps as a result of caste distinctions on the one hand and a sort of mutual aloofness of the scholars on the other. Thus the training of the mind did not go side by side with the training of the hands. These two activities which are now commonly referred to as Science and Technology were isolated from each other on the Indian scene. There

was no plan or policy to link these two activities of mankind - activities which now seem to be inseparable in the present context of the society. It appears that the lack of a policy providing a linkage between science and technology may have led to the gradual decay of the creative endeavour of high calibre in India after the twelfth century A.D. The fact that the two activities could be complementary to each other was never realized by the then policy markers of India. The policy and decision makers of the ancient past had never envisaged the role that science and technology can jointly play in the development of society. It was only through the impact of the Western Science, through the work of Scientists and Technologists of Italy, France, England and Germany, over the Sixteenth, Seventeenth and Eighteenth century, that the new concepts of modern science and the role it plays in the development of society, have evolved and have had a renewed impact on the Indian scene. The Industrial Revolution which had its origin in the west had bypassed the scholars and the professional workers of India. The opportunity of harnessing our human resources in the two fields of Science and Technology, through planned policy, had been lost as a result of our traditional compulsions and political vicissitudes. It is only as a result of the technological renaissance in Europe, the age of the Industrial Revolution, that we saw a renewed impact of Science - the so-called Western Science - In India which led to an organised activity of a different kind, based on a policy involving political ambitions, commercial utilization of natural resources, and the need for obtaining the climatic and geographical knowledge of the country. This impact of Western Science in India led to an era of institution building through the foundation of professional societies, scientific surveys and institutions, educational systems and industries based on modern science and technology. The policy for laying such foundation for S&T in India was no doubt based primarily on the self-interest of the British, but it never-the-less provided, for the first time in Indian history, a base for planned activities in Science and Technology

Another aspect of the formulation of policy for Science is closely linked to the potentialities which science promised in the area of war. The Second World War period saw the growth of scientific development in the West which gave birth to systems such as Radars and subsequently to the developments of the atomic weapons of frightening power. Scientific techniques of Operations Research were developed and utilized for coordination and direction of military operations. All these activities needed a well planned policy for the utilization of science and technology; India, which was then under the colonial rule of the British, was obviously not involved actively in this process. In a sense this was unfortunate since the very same

planned developments in Science and Technology which gave the weapons of war could as well have been used for peaceful purposes as is evident from the developments in electronics, aeronautics and communication. India could systematically plan for these developments only after it was an independent country.

With the rapid growth of Science and with its impact on the development of technology, as evidenced through the Industrial Revolution, it increasingly became clear that a well planned policy for the utilization of Science and Technology was needed if the process of rapid industrialization was to be used as means for the development of the country. The triad of Science, Technology and Development has increasingly started drawing the attention of the world community and it was becoming clear that science was no magic band which when coupled with technology would easily result in the required development of society. There were a number of issues such as the environment in which S&T would have to operate, the traditional and cultural values which have to be suitably transcended, the evil effects of war to be avoided, the commercial interest of exploitation to be guarded against, as well as a number of complex socio-economic factors had to be taken into account. Developments in S&T, if they have to result in providing, to the people, the required goods and services such as food, through appropriate application of new techniques in agricultural science, health care through new developments in medicine, industrial products through improved use of existing materials and innovation of new materials etc., it will be necessary to formulate precise policy guidelines for various sectors such as Industry, Health care, Agriculture, etc., where S&T can play a prominent role in bringing about the desired change.

The formulation of policy for application of Science and Technology is thus a very complex phenomenon which has evolved only gradually in our country over several decades. With the emergence of an Independent Nation and the conscious decision of the Government, India has seen a marked change in its approach to S&T. The following sections will deal, in detail, with these changing approaches in formulating a national policy towards the growth of S&T in the country.

II. DEVELOPMENT OF SCIENCE IN THE PRE-INDEPENDENCE PERIOD

India differs from many other developing countries in that it had a flourishing scientific tradition in the ancient and medieval periods. The development of modern science in our country is however not an organic extension of this earlier tradition. It is the growth of an implant by the British in a

language that was alien to our people. Modern science in India thus constitutes a break from its historical antecedents. Thus the rulers of a country tend to play a very major policy, role as to how science is allowed to grow in that country.

(a) *Sporadic growth of Institutions:*

In pre-independent India, science developed in an uneven, superficial and patchy way. Institutions were set up mainly to provide a science data base which could be utilized as and when required for the operations to be carried out in the country. Institutions such as Survey of India, Geological Survey, India Meteorological Department, etc. are examples of such an approach. Later, the foundation for basic sciences was expanded and academic science in universities received a fillip. The Indian Science Congress was inaugurated in 1914, the Indian Academy of Science in 1934 and National Institute of Science in 1935. Setting up of such professional societies was perhaps the result of the initiative taken by individual members of the scientific community and it remained always an academic exercise, this had its own influence on the future growth of science in the country. In all this process the development of Technology always lagged behind and when introduced, it was very often imitative or outright imported into the country.

(b) *The effect of World War II - Early efforts at Planning*

The outbreak of the Second World War in 1939, brought about a radical change in the pattern of scientific and technological research in India and the need for a strong Industrial Research Institute was felt. The colonial Government being cut off from Britain, was forced to actively develop local resources to meet the demand of war and strive to become industrially self-sufficient; the establishment of a Central Research Organisation became essential and this was eventually followed by the establishment of the Council of Scientific and Industrial Research, as an autonomous society, in 1942. Since then, this Council has been playing a prominent role in fostering scientific and industrial research in India.

As a part of India's post-war reconstruction plan, in 1943 the Government of India invited Prof. A.V. Hill for discussions on the organisation of scientific and industrial research. On the basis of his recommendations, the Government of India set up a Scientific Consultative Committee for Planning and Coordination of Research,administered by various departments. Further, another important step was taken early in 1944 by the CSIR by establishing the Industrial Research Planning Committee to make a comprehensive survey of the existing facilities for scientific and industrial research in

India. The reports of Prof. Hill and the Industrial Research Planning Committee were considered by the Scientific Consultative Committee and it was decided to prepare a scheme for the Central Organisation of Scientific Research on the basis of the proposals contained in the reports. These two reports had a major influence on the development of science and technology in the post-independent India.

With all these developments, it is evident that the importance of the role of science and technology in economic and social development and the need for science and technology planning was realised by India even before India attained her independence. In 1939 itself, Indian National Congress appointed a National Planning Committee and invited leading scientists to participate in the formulation of plans for economic development and social betterment. It was envisaged that planning is the only way through which a country could be put on the road of self-sufficient growth and science and technology was given the necessary importance and significance.

III. DEVELOPMENT OF SCIENCE AND TECHNOLOGY IN THE POST-INDEPENDENCE PERIOD

(a) *The Process of Institution Building.*

After the National Independence in August 1947, the Indian Government, under the dynamic leadership of the then Prime Minister, Shri Jawaharlal Nehru, put itself to the task of the socio-economic transformation of the country through a process of planning and science was given considerable importance in the plans and its significance in national development was soon recognised. It was the firm belief of Shri Jawaharlal Nehru that science and technology can play a major role, in accruing to the people of India, the benefits that can be harnessed from a planned pursuit of science and technology. This commitment to science and technology led to the setting up of an extensive institutional network and a chain of research laboratories in the country under the guidance of a scientist like Dr. Shanti Swarup Bhatnagar.

Realizing the future importance of atomic energy in the national development, the Atomic Energy Commission was formed in 1948 under the Atomic Energy Act of 1948. A topmost Scientist of the calibre of Dr. Homi J. Bhabha was given the status of a Secretary and the Department of Atomic Energy was set up in 1954 with considerable amount of autonomy. This was a major shift in policy in government administration.

Soon after independence, the entire field of education was reviewed by an Education Commission set up in 1948 headed by Dr. S. Radha-

krishnan. Its recommendations had considerable impact on the growth of universities in the country. University Grants Commission was set up in 1956, which had considerable effect on the expansion of facilities for teaching and research in universities through its research projects, fellowship programmes etc. Further, an important step taken by the Government was to establish five higher technological institutions to develop facilities within the country for advanced technological training and research.

Until 1930s, application of science and technology to defence was very limited and was confined to testing defence stores and equipments. The second World War established the need to set up laboratories for studying other aspects related to defence, such as, technical problems conected with procurement, maintenance, modification of military equipments, utilization of indigenous materials etc. The Defence Production Board was also created to provide an integrated control over research, development, production and inspection. In 1958, the Defence Research and Development Organisation (DRDO) was formed by amalgamating the existing organisations and with this step, an adequate organisation was established to meet the growing science and technology needs of the defence sector. Once again, an eminent scientist of the calibre of Prof. D.S.Kothari was appointed as the Scientific Adviser in the Ministry of Defence and also the Director-General of the DRDO.

(b) *A Policy for Science and Technology*

With all the post-Independence developments and deliberate efforts for a planned economy, post war developments in science and technology compelled the Government, in 1958, to have a closer look at the machinery for science and technology with a view to make them more effective. It was felt that scientific and technological research needs huge investments and calls for a judicious utilization of scarce resources like raw material, trained manpower and technological skills available in the country. In short, a need was felt for formulating, what has now come to be known as, a National Science Policy. Though it is rather difficult to define science policy in clear terms, the science policy of a country is an expression of (i) government assessment of the national research and development efforts, (ii) definition of objectives, and determining priorities for promoting and utilizing science and technology, and (iii) of programming and coordinating of research in different sectors along with the requirements of trained manpower so as to obtain the maximum benefits out of the resources expended. The science policy of any country cannot be blind to the future research and technological needs and, hence, it is a determinant of a continuous process of thinking and sustained action. In the light of this conceptual

framework and the keen desire of the Government to give importance to science and technology in the national development, the Government proclaimed the Scientific Policy Resolution in 1958 (Annexure-I). The orign of this document which was the outcome of the commitment to science under the political leadership of Jawaharlal Nehru and the concerned of the scientists like Homi Bhabha for benefiting mankind through the pursuit of science, is a unique example of the process of science policy formulation in India. The Scientific Policy Resolution indicated the Government's intention to support science and technology in order to "secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge".

In May 1956, the Government had set up a Scientific Advisory Committee to the Cabinet (SACC), with explicit and wide ranging terms of reference to advise the Cabinet in the "formulation and implementation of Government's scientific policy". In 1968, the SACC was replaced by the Committee on Science and Technology (COST) with somewhat wider and enlarged terms of reference than that of SACC so as to encompass the field of technology as well; the important function being to advise the Government on the formulation and implementation of Government Policy on Science and Technology. Also, in order to establish effective linkages with the Planning Commission, Member (Science) in the Planning Commission was appointed as Chairman of COST. In addition, the Government of India established a Standing Group of Ministers on Science and Technology under the Prime Minister's Chairmanship to review the progress of science and technology and take an overall view of the scientific effort in the country.

With the announcement of the Scientific Policy Resolution (SPR), the objectives of the Government in developing science were clearly set out. Several organisations, institutions and universities were already existing and they had to be persuaded to accept the new dimensions of the science policy. As part of its work, SACC took various measures for implementation of the SPR and it took up one of the important tasks of examining the organisation of the institutes and laboratories. The Government was not only keen to support the growth of science and technology in the country but was anxious to ensure that a proper institutional mechanism is also established with it. This must be considered a major aspect of its policy implementation programme.

At this stage, as an example of how science and technology policy formulation in post-independence era had been affected by political developments and socio-economic factors, it is worthwhile quoting the developments in the area of electronics. Soon after the Chinese invasion of 1962,

Dr. Homi Bhabha recognized the appaling dependence of India on foreign sources in the whole field of electronics, so vital not only to defence but also to national development. In 1963, a Committee under the Chairmanship of Dr. Bhabha was appointed by Government to look into the whole area relating to development of electronics in the country. The Committee attempted to analyse in a total manner, this fast moving and sophisticated industry and associated technology; the objective was to achieve a self-reliant growth of a strong electronics industry, since it was felt that it is a vital element for industrial growth and for strategic areas such as defence and communications. The Bhabha Committee report recommended how the electronics industry has to be considered as a whole and developed in an integrated and interlocked manner. As a result in February 1971, the Electronics Commission was set up by the Government to plan the various aspects of growth of electronics in the country. The setting up of Electronics Commission was a major Government decision in its science policy implementation process.

(c) *Review of the Scientific Policy Resolution:*

In order to fulfilment the aims of the Scientific Policy Resolution, the Government of India also decided to seek the advice of the scientific community. As a result, three Conferences of Scientists, Technologists and Educationists were held in the period 1958 to 1970, to discuss measures for its implementation. The Third held in November 1970 took note of the fact that the broad objective of the Scientific Policy Resolution is to acquire for the people of the country, all the benefits that can accrue from the acquisition and application of scientific knowledge. It was necessary to grow, foster, promote and sustain the cultivation of science in the country, identify and train the appropriate manpower required for the same. It is necessary to identify various sectors of the economy where science and technology could be applied. Appropriate programmes would have to be drawn out in each of the sectors and appropriate institutional mechanism set up within the country to ensure that inputs from science and technology are made available in these sectors. The question of allocation of adequate resources for R&D activities of the country had to be examined in detail and its linkage with the gross national product (GNP) had to be established. In the productive sector, it was necessary to ensure that research and development programmes carried out in the laboratories, wherever applicable, should be transferred to the productive centres; whereever technologies have to be imported from outside, industry would have to take measures to ensure that only the most appropriate technology needed for the country is imported and assimilated through appropriate technology assessment and

avoid repeated imports. The Third Conference of Science, Technologists and Educationists,therefore,discussed four specific topics namely,Science Policy, Climate of Science and Management, R&D in Industrial Development and Higher Education and Manpower. The Conference was of the view that the Scientific Policy Resolution of 1958 is an admirable enunciation of the Government's faith in science and the role science must play in the transformation of our society. It was considered essential that a national Science and Technology Plan must be prepared which should be congruent to, and form an integral part of the overall economic plan of the country. In order to achieve this, a national body at the highest level was proposed to be set up which should be called the National Committee on Science and Technology (NCST), which should have close links with the Planning Commission. Several steps were suggested for bringing about a change to enable participation and sharing of responsibility by scientists at all levels.

A number of suggestions were also made to streamline the existing personnel policies so as to bring about a better climate of research in the country and to ensure retention in the country and transfer within agencies, laboratories and universities of scientists and technologists. With regard to R&D and Industrial Development, the basic criteria was the achievement of self-reliance in order that our investments were not wasted but led towards a "take-off". The Conference favoured a dual approach, namely, the integrated approach between research, design, engineering, marketing, which has been found to be successful in some major industrial areas, such as fertilizer, railways and atomic energy, and the other approach, to have the various activities under separate management, but with close linkages such as those being followed and found successful in the field of petroleum, etc. It was therefore felt that individual areas would have to identify the approach that would be most suitable for its successful organisation. The Conference also expressed considerable concern about the fact that while there were a number of specific needs of development, requiring a large number of technically trained persons, quite a number of these persons in the country were unemployed, while a good number of them had migrated abroad. The planning for training of scientific manpower was to be based on the requirements of the national science and technology plan. The need of doubling the total resources spent on scientific research and development in the academic sector over the next five years was considered the minimum needed.

As a result of the recommendations of the Third Conference of COST and the need felt for preparing an overall Science and Technology Plan in 1971, the Government decided to establish a National Committee on Science and Technology (NCST) which replaced the Committee on Science

and Technology. One specific mandate of the NCST was the preparation, evaluation and updating of national scientific and technological plans. The role and functioning of NCST would be discussed later in the context of Integrated Planning for Science and Technology.

IV. INFRASTRUCTURE FOR IMPLEMENTING SCIENCE AND TECHNOLOGY POLICIES

Since the enunciation of the Scientific Policy Resolution and the recommentations of the Third Conference, scientific activity quickened in pace and broadened in scope and a substantial infrastructure of institutions and capabilities in several fields, from agriculture through medicine to defence, atomic energy, space, electronics and a host of other industrial technologies, has been built. A very brief description of the S&T infrastructure which have resulted from these policy guidelines follows in the subsequent paragraphs. The major achievements through such institutional infrastructure are given in subsequent section. The organisational chart of the national S&T activity is given in Annexure-II.

(a) *Scientific Agencies of the Government*

Science and Technology activities in the country are mainly carried out through the scientific agencies. These are: Council of Scientific and Industrial Research (CSIR-1942); Indian Council of Agricultural Research (ICAR-1947); Indian Council of Medical Research (ICMR-1949); Department of Atomic Energy (DAE-1954); University Grants Commission (UGC-1956); Defence Research and Development Organization (DRDO-1958); Department of Space (DOS-1972); Department of Electronics (DOE-1971); Department of Science and Technology (DST-1971) and the recently established, Department of Environment (DOE-1980).

In addition to the scientific agencies, the Government has a number of research institutions and public sector undertakings which are attached to the various economic ministries for carrying out research programmes of practical application in their respective fields such as irrigation, energy, telecommunications, etc. Also, an increasing number (600) of public sector undertakings and private sector enterprises carry out research in their respective fields through their own R&D units. Research in Universities is carried out with the support of University Grants Commission and through the sponsorship of the various scientific agencies. There are also a number (more than 100) of professional bodies, like the Indian National Science Academy (INSA), Indian Academy of Science (IAS), National Academy of Science, etc. who are also concerned with promoting Science and Techno-

logy in the country. State Governments maintain research institutions in selected areas of relevance to them and State Councils on Science and Technology have also been set up in some States. The activities of the various Science and Technology institutions, as described above, constitute an integral part of the National Science and Technology endeavour.

(b) *National S&T Manpower*

The Scientific Policy Resolution of the Government of India had given considerable emphasis to the development of S&T manpower, its proper training, necessary encouragement required for individuals, and through various other means such as by offering good conditions of service to scientists and according them an honoured position, by associating scientists with the formulation of policies and by taking such other measures as may be deemed necessary from time to time to accomplish the aims of the Scientific Policy Resolution. It is because of this concern for S&T manpower that, in addition to the provision of infrastructure of S&T institutions, considerable attention has been given to the most important input needed for development of science and technology viz. the qualified S&T manpower. The stock of S&T personnel has been growing steadily; during the last 25 years it has increased 7 fold. There is an annual output of over 1.5 lakhs in the form of graduates from universities. S&T personnel, as of 1978, are estimated at 19 lakhs (Annexure-III). Even though, India has a large S&T manpower (third largest in the world), relatively small portion of them are engaged directly in R&D activity. Further, in recent years, there has been considerable amount of concern being expressed that the best of our technical talents are being diverted into areas such as management, banking etc. which are not directly connected with their technical professions. This aspect is being looked into and necessary steps will have to be initiated to ensure that such diversion of talents is prevented. This becomes particularly important when one realises that in the growth of science, as new and emerging fields like genetic engineering, microprocesser technology etc. appear on the scene, one requires the best of talents to pursue these and where traditional training is not always beneficial. As a specific example, one could cite the case of a major public sector undertaking which is presently looking for highly qualified polymer scientists; but they are not available in the country. Therefore, new innovative approaches are required for taking up inter-disciplinary areas of research for which only the best talents are required and should be generated at any cost.

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(c) *Institutional Mechanisms for Import and Utilization of Technology*

As regards the implementation of the policy related to import of technology and foreign investment is concerned, it is guided by the Industrial Policy Resolution which dates back to 1956. This Industrial Policy has undergone a number of changes but basically the policy recognises the necessity for continued flow of technology in areas not adequately developed. Indian firms which are to import foreign technology are required to set up in-house R&D facilities so that imported technology is properly adapted and assimilated. Matters relating to foreign and technical collaboration, both in Public and Private sector are handled by the Foreign Investment Board, headed by Secretary, Department of Economic Affairs, and consisting of the representative of Directorate General of Technical Development, Department of Science and Technology, Ministry of Commerce, Department of Economic Affairs, Development Commissioner, Small Scale Industries, and other concerned Ministries. This Board is assisted by a Technical Evaluation Committee and serviced by the Secretariat of Industrial Approval (Department of Industrial Development). Foreign investment has played a progressively diminishing role in the recent past and as per the present Foreign Exchange Regulation Act (FERA), foreign equity is welcomed only if it brings technological know-how which cannot be otherwise brought or assimilated. FERA has particularly played an important role in controlling the operations of foreign multinational companies in the country.

As far as the technology transfer from national R&D institutions to industries in India is concerned, it takes place through the National Research and Development Corporation of India (NRDC), set up in 1953. The R&D institutions offer their processes for commercial exploitation to the NRDC. Further, there are a number of consultancy and design organisations which have grown in the recent past (presently numbering around 150) and these firms have expertise in a wide range of processes and products and contribute to the process of technology transfer.

With regard to promotion and utilisation of indigenous technology, the Department of Science and Technology has set up a number of mechanisms for recognising R&D units in the Industry and promoting liberal incentives to them; free licensing of industries based on indigenous technology, provision of increased investment allowance for using indigenously developed technologies, etc.

V. INTEGRATED PLANNING FOR SCIENCE AND TECHNOLOGY

In October 1971, the National Committee on Science and Technology (NCST) was set up as a successor body to CoST and besides being an advisory body to the Government on S&T matters, one of the specific mandates of NCST was the preparation and continuous updating of the national S&T plans as integral part of the socio-economic plans. Before we discuss the approach taken by NCST towards planning for S&T, it may be worthwhile examining the three main levels which are involved in our S&T planning system.

(a) *The Three Planning Levels for S&T*

The Science and Technology system in India may be viewed at three levels, namely, (i) the National level, (ii) the Agency level, and (iii) the Institutional level.

The National level takes into account the overall needs and the problems of the country based on the socio-economic objectives of Government. The National Planning Commission considers the plan for science and technology as a part of the overall socio-economic plan. The problems at the national level include establishing the priorities for different sectors of research in individual agencies/ministries concerned and allocation of resources to them, generating scientific and technological potentialities to achieve the national objectives.

The second level consists of scientific agencies and other ministries/ departments of Central Government. At this level, the plans are formulated in the light of the broad guidelines indicated at the national level (for details please see Annexure IV).

The third level is the institutions/laboratory level. At this level, detailed research projects/programmes are formulated, taking into account the progress of science and technology in their specific fields and also the priorities indicated by the agency to which these institutions belong.

The main task of integrating the S&T planning with the socio-economic plan objectives thus depends very much on how the three levels of the planning system are able to mesh into each other in a co-ordinated way. The exercise undertaken by NCST in this direction will now be discussed in the following paragraphs.

(b) *The NCST approach - The 1974-79 Plan*

Planning for S&T in relation to socio-economic objectives is a relatively new concept in India. While S&T permeate almost all areas of national activity, until the Fifth Five Year Plan, Science and Technology Planning

in terms of objectives and programmes, processes and techniques to be developed and technological capabilities to be acquired, had been mostly confined to a few scientific agencies and allied departments, in particular, Agriculture, Atomic Energy, Space, CSIR and Defence, where an integrated system's approach has characterised the planning and execution of programmes. In other sectors, however, the S&T effort has remained largely fragmentary and it was important to foster co-ordination and make an optimal use of complementary expertise and facilities that existed under different laboratories/ministries and to supplement them where necessary so as to develop a total systems capability. For example, in the area of communications the capabilities represented by Telecommunication Research Centre (TRC) and Indian Telephone Industries (ITI) as well as ECIL, ISRO, BEL and DRDO had to be harnessed for a common purpose.

A systems approach has also been missing in the economic ministries concerned; the S&T awareness and absorptivity for S&T inputs has, therefore, remained inadequate, and correspondingly, S&T tasks crucial for our economy, have often remained unattended for want of a proper mechanism to identify these tasks and assign them through a proper mechanism to appropriate national institutions. Services in areas like health, housing irrigation, power and meteorology have suffered as a consequence. Also, the country has remained dependent on, and even subservient to, imported technology in several areas.

The setting up of the National Committee on Science and Technology in 1971 (NCST) was an important step towards systematic planning of science and technology for development. As a first step, the NCST brought out in 1973, a policy document entitled "an approach to S&T Plan", wherein it was envisaged that the NCST would proceed on the basis that national investment on R&D during the Fifth Plan would be such that a figure in the neighbourhood of 1% of the GNP, is likely to be available for R&D in the last year of the Fifth Plan. This had been broadly accepted by the Standing Group of Ministors on S&T in 1971.

On this basis, the NCST undertook the major task of formulating the nation's first S&T Plan. It adopted a sectoral approach, identifying 24 major sectors, in order to take a systems view of science and technology development. Planning in terms of sectors has been of great signficance, and has brought out the role that science and technology can play in the economic development of that sector and how the national infrastructure in S&T could be utilised. The sectoral approach helps in focussing on past imbalances and suggesting S&T programmes to correct them.

The task of formulating the country's first plan was undertaken with active participation of two thousand scientists/technologists drawn from different areas of spocialisation. These included technical personnel belonging to various ministries, industries, R&D organisations and academies. The involvement of these experts was, however, in an individual capacity so that they could review and choose without being constrained by existing departmental policies.

This exercise undertaken by the NCST in 1972-73 resulted in a basic document reflecting the sectoral needs, areas of thrust and possible avenues for extending known scientific and technological skills. The first draft of the S&T Plan was discussed by the NCST with the Planning Commission. In the Science and Technology Plan, programme were designed to have a major socio-economic impact and the main emphasis was placed on inter-disciplinary and multi-institutional projects, as well as on sponsored projects and in-house R&D in industry. Attention was focussed on enhancement of science and technology inputs in areas like Khadi and Villages Industries, energy exploration and exploitation of natural resources, agriculture, fertilizers and chemicals, coal, steel and mines, waste utilization, etc. In addition, a number of research programmes were initiated with specialised areas like Atomic Energy, Space, Electronics, Medical Research etc. Three important features of this S&T Plan have been: (a) laying as much emphasis on the development of engineering, design and fabrication skills as on the development of process/product technology (b) making the existing science and technology infrastructure more effective through the provision of additional facilities, rather than creating new organisations, and (c) emphasizing rural development.

With regard to the role of basic sciences, a number of mechanisms were suggested in the S&T Plan to support research in higher educational institutions. It was noted that application of S&T demands, in the first instance, a strong foundation in basic science, and for promoting this, the Science and Engineering Research Council was recommended to support and foster basic scientific and engineering research in new and emerging areas. Many of these schemes would have to involve collaboration between university departments, IIT's and CSIR laboratories. The plan also suggested that the increasing support to research had to be purposefully utilized by the universities, to develop S&T capability.

In the S&T Plan, the NCST projected a plant outlay of Rs.1725 crores, against which the Planning Commission in its Draft Fifth Five Year Plan (1974-79) made a plan provision of Rs.1033 crores, which was later on reduced to Rs.767 crores in the final Fifth Five Year Plan document'. This resulted in imbalances in a number of sectors and the allocations for

S&T in different sectors (other than those areas of scientific agencies) had no relation to what had been proposed by the NCST in the S&T Plan and this situation became even worse if one looked at the actual expenditure in various sectors in the truncated Fifth Plan (1974-78) (Table-1).

TABLE - 1

S&T outlays proposed by NCST, outlays provided by Planning Commission, and actual expenditure, in a few major sectors.

(Rs. in Crores)

Ministry/Agency	Plan outlay 1974-79 proposed by NCST	Plan outlay 1974-79 provided by Plg.Commn.	Actual Plan expr. 1974-79	% of Actual Expr. to plan outlay
C.S.I.R.	187.85	81.71	54.17	66%
I.C.A.R.	114.86	153.56	105.72	69%
D.A.E.	159.33	167.13	105.35	63%
Deptt. of Space	141.22	128.27	86.29	67%
Deptt. of Electronics	88.00	18.73	9.10	49%
Deptt. of Science and Technology	109.16	58.96	41.12	70%
Heavy Industries	268.36	28.76	12.72	44%
Shipping & Transport	47.76	2.98	0.94	32%
Irrigation & Power	130.86	17.17	3.38	20%
Works& Housing	29.28	0.53	-	-
Petroleum and Chemicals	62.21	14.43	7.31	51%

Sources: Science and Technology Plan 1974-79, Volume I, Draft Sixth Five Year Plan 1978-83 (Revised).

The Planning of S&T in respective states, in an integrated manner, had also been attempted during the Fifth Plan period when State Committees for S&T were constituted in some states at the instance of NCST. Seventeen States Research, Design and Development (RDD) Committees had been sent up under the joint auspices of Ministry of Industrial Development and the Department of Science and Technology and these scruitinise problems which are posed by the industries in the small scale sector and assist the Small Industries Services Institute (SISI) established by the Small Industries Development Organisation (SIDO).

In order to promote Research, Design and Development (RDD) in Industry, several measures were envisaged in the S&T Plan. Substantial tax concessions have been permitted to industrial firms and rules for import of equipment, instruments, raw materials and spares for RDD purposes have been liberalised and a scheme for registering of R&D units of companies was instituted under the aegis of the Department of Science and Technology. Measures were also envisaged for preferential treatment to companies for taking up ventures based on indigenous technology.

The Science and Technology Plan provided a useful chek-list of programmes and projects that needed to be undertaken. However, in the absence of an assigned responsibility and a mechanism for fixing priorities, identifying tasks and projects and allocating resources to appropriate institutions for carrying these out and thus enmeshing the S&T Plan into the sectoral socio-economic plans, and for ensuring its implementation, monitering and review, the NCST plan of 1973 remained largely unimplemented. An approach to a desirable mechanism could only be devised midway through the Fifth Plan when the Planning Commission, at the instance of NCST/DST, started holding separate discussions on the S&T component of the Annual Plan with each economic Ministry/Department.

These have helped to create, in those administrative Ministries where the S&T base has been weak, a greater awareness about the S&T inputs which could further their sectoral economic objectives. As a part of this process, separate S&T Budget heads have been created in various Central Ministries and Special Committees for Implementation of Projects (SCIP) have been set up in a few of them. These have been some important steps towards faciliating the Planning and Implementation of S&T Plan (1974-79).

Though the efforts of NCST in S&T Planning were commended by the scientific community, the implementation has been rather slow. While preparing the plan itself, the NCST was seized of the enormous problems in implementation and found it necessary to add an AFTERWORD to the NCST document "An Approach to S&T Plan", which states:

"The task of implementing the Science and Technology Plan will make heavy demands upon the machinery of Government. But, however, heavy the demand and however great the challenge, all of us must resolve to meet it; for, we can formulate and we can project; we can envisage and we can programme; we can define and we can budget; but if we cannot implement with speed and efficiency, we would have failed a new generation and forfeited our mandate to Plan".

(c) *A New Five Year Plan (1978-83)*

With the change in Government, midway in the Fifth Plan (1977), there were a number of policy changes and the Fifth Plan was terminated a year earlier (1978) and a new draft Five Year Plan (1978-83) was prepared. A new concept in planning namely the "Rolling Plan" system was introduced with the following features:

i) Year to year targets will be set for sectoral outlays and output for major sectors within the Five Year Plans;

ii) The horizon of the Five Year Plan will be extended by working out these selected sectoral targets for one additional year at the end of each year.

The Principal objectives of the Draft Five Year Plan (1978-83) were identified as follows:-

"..... achieving within a period of ten years:

i) the removal of unemployment and significant under-employment;

ii) an appreciable rise in the standard of living of the poorest sections of the population;

iii) provision by the State of some of the basic needs of the people in these income groups, like clean drinking water, adult literacy, elementary education, health care, rural roads, rural housing for the landless, and minimum services for the urban slums.

The plan aims at considerable progress towards achieving these goals.

These primary objectives should be attained while

iv) achieving a higher rate of growth of the economy than in the past;

v) moving towards a significant reduction in the present disparities of incomes and wealth; and

vi) ensuring the country's continued progress towards self-reliance".

The new plant also contained in 'S&T Chapter' where broad policy issues and approach to 'S&T Planning and Implementation' were discussed. The basic objectives of S&T Plan (1978-83) had been to secure for the people of the country *particularly in the rural areas* all the benefits of S&T. The NCST was also reconstituted in July, 1977 with a major change that the mandate for S&T Planning was dropped. NCST emphasised the need for application of S&T, particularly towards rural development, and also proposed a Technology Policy Statement with adequate emphasis on Rural Development. As a part and parcel of the New S&T Policy of bringing industry and research laboratories together, some laboratories of CSIR were transferred to the concerned socio-economic ministries on an experimental basis. Also, the need for specific measures to promote R&D in industry was emphasised and a National Registry of Foreign Collaboration was recommended. The new Plan (1978-83) identified the need for creating an effective mechanism within the Planning Commission and within the economic ministries to take responsibility for a number of inter-related functions, so that S&T Planning may become an integral part of socio-economic planning. In particular, the setting up of professional information planning and analysis groups was felt necessary to provide technical back-up to the economic Ministries. The need for proper machinery for S&T Planning and implementation was thus conceived in the plan framework for 1978-83.

The outlays for science and technology efforts in the 1978-83 Plan programmes are broadly categorised under two groups. The first group consists of S&T agencies and the second consists of S&T in other ministries/departments. A total picture of the S&T Plan outlay is presented in Annexure-IV. An analysis of these outlays brings out the following selient points.

- o The S&T efforts in the Ministries other than the agencies (DAE, ISRO, DST/CSIR) have shown some increase due to planned efforts during the previous 5 years. This is seen from the fact that while these Ministries accounted for 16 per cent of the total public expenditure on S&T in 1974-75, they account for 32 per cent in 1979-80.

- o The Ministries other than agencies account for 30 per cent of the S&T Plan outlay (1978-83) compared to the 22 per cent in the Fifth Plan (1974-79).

- o The R&D expenditure in some of the public sector undertakings has started picking up as a result of planned efforts. It has increased from 5.8 per cent in 1974-75 to about 11.5 per cent in 1978-79.

- The S&T expenditure in the Industry has started increasing as a result of planned efforts and has increased from 14% in 1972-73 to 24% in 1978-79. (Annexure-V).

(d) *The Sixth Plan - S&T Plan Framework for 1980-85*

After having prepared the 1978-83 plan for S&T, introducing together with it the concept of rolling plan, providing for an annual review, the Janata Party Government (which was in power only for a short period viz. March 1977 to July 1979) could not undertake the implementation of even the first year of its 1978-83 plan. With the coming of the Congress party back to power in January 1980, the reconstituted Planning Commission, at its first meeting held in April 1980 under the Chairmanship of the Prime Minister, Smt. Indira Gandhi, decided that there should be no Plan holiday and that the Sixth Five Year Plan should cover the period 1980-85.

In order to evolve a draft S&T Plan framework 1980-85, consultations were started by the Planning Commission in April 1980. Working Groups were set up in selected sectors which included component for science and technology. Simultaneously, Planning Commission held discussions with the heads of scientific agencies to identify new S&T proposals which could be included in the new Five Year Plan 1980-85.

Further, at the instance of the Prime Minister, a meeting of scientists from different agencies and disciplines was held in August 1980 with a view to evolve an approach to S&T Plan and to identify areas of thrust for the S&T component of the Sixth Five Year Plan. As a follow-up of this, Planning Commission constituted a Core Working Group on science and technology for the Plan 1980-85, mainly for considering the priorities in S&T and evolve guidelines for investment in science and technology in an integrated manner. The working group took note of the fact that the country had provided increasing amount of financial resources to S&T activity (Table 2) in the past and considerable amount of infrastructure in S&T, in the form of manpower and institutional structures, had been set up and there was a need to mobilise it effectively for national development. At the same time, looking at the overall growth of S&T that had taken place on the global scale, and realizing that India could not afford to lag behind in its march towards S&T development, the group noted that there was an urgent need to give special thrust in some of the new areas that had emerged in S&T which are not only in the frontiors of knowledge but have indicated potential application for human development. To cite a few examples one can look at the advancements in molecular biology and genetic engineering; modern developments in lasers and in microelectronics with their wide range of applications. The S&T component of the Sixth-Plant (1980-85) is given in Annexure VII.

TABLE - 2

Financial Resources Provided in Successive Plans

(Rs. in crores)

	Plan	Non-Plan	Total
1st Plan (1951-56)	14	6	20
2nd Plan (1956-61)	33	34	67
3rd Plan (1961-66)	71	73	144
4th Plan (1969-74)	142	231	373
5th Plan (1974-78) (Truncated)	502	515	1017
6th Plan (1978-83)	1376	1069	2445
6th Plan (1980-85)†	1919	1448	3367

Source: Planning Commission

Keeping these concept in mind and in order to achieve the overall socio-economic objectives of the Sixth Five Year Plan, some of the criteria which had a bearing on setting the goals and charter for S&T plan, relate to:

(a) maximising the returns from investments already made in several sectors of the economy and there by bringing about fuller utilization of the capacities through the increase of efficiency and productivity.

(b) ensuring appropriate steps to achieve technological self-reliance through application of modern science and upgradation of technology.

(c) structuring the application of science and technology in different sectors around the theme of conservation and efficiency in the use of energy and appropriate materials systems.

(d) bringing about conditions which enable the adoption of science and adaptation of technology oriented to the provision of benefits to the society.

(e) ensuring that the development programmes based on science and technology are compatible with the goal of protection and improvement of ecological and environmental assets.

(f) ensuring its potential for securing a faster growth in the economy commensurate with the improvement in the quality of life of our people and the inculcation in them of a scientific temper.

Some immediate measures relating to the utilisation of S&T in national development have also been suggested in the Working Group on S&T plan. Some of these are:

- Development of State Councils on Science and Technology in order to promote and coordinate S&T activities at the State level.
- Organization of young and bright scientists in promoting the interest in science and in studying the culture of science to the needs of the country.
- Involvement of national science academies and professional bodies in the S&T development process.
- Building up a national rural resources corps of young professionals.
- Development of S&T programmes for Scheduled Castes and Schedule Tribes and other weaker sections of the society.
- Selective intensification of research work in high priority areas like fertility control, immunology and vaccine production, integrated energy systems and producer oriented agricultural marketing.
- University system has a high quality scientific manpower and support for university research has to be enhanced in order to improve the research output.
- Promotion of scientific and technical cooperation particularly with the developing countries in order to identify and take up programmes of collaborative nature for collective self-reliance of the developing countries, and strengthening India's position in the third world.

The Working Group has emphasised the importance of creating, on an urgent basis, appropriate instruments relating to policy formulation, S&T planning and implementation. The need has also been expressed for having, in the economic ministries, properly structured information planning and analysis groups staffed with professional scientists and technologists. It is emphasized that in all areas of priorities in the plan, where large investments

are to be made, the S&T component is clearly identified and broken down into specific tasks that can be assigned to institutions capable of working on them (whether coming under the concerned ministry or otherwise) and where necessary, new capabilities built up. Several other suggestions have also been outlined, based on past experience, for providing a linkage between the scientific community, R&D, industry, technology acquisition and adaptation, foreign collaboration in S&T etc.

While the S&T Plan is on the anvil and its implementation will no doubt depend on the efficient use of the resources, the major objective of integrating the S&T plan with the socio-economic plan can only be achieved if S&T is not viewed as a separate component of the plan; S&T should be able to permeate and subserve every sector of the economy and become as essential and integral part of the national development process. As long as this does not happen there is a danger that our S&T capability will begin to decay for want of effective utilization. In this context the decision of the Government to set up Cabinet Committee on Science and Technology and Science Advisory Committee to the Cabinet are major steps which should assist in implementing S&T Plan of 1980-85.

(e) *The impact of S&T Planning*

As a result of these planned efforts, there has been a rapid development of scientific and technological activity in India since 1958, which is reflected in the substantial increase in the resources devoted to research and development and in the number of people engaged in science and technology activity and in the number of S&T institutions built up in the country. The magnitude of the annual science and technology expenditure (1976-77) is around Rs.450.0 crores (see Annexure - VI) i.e., 0.6% of the GNP. This may be compared with 1% of the GNP recommended by the NCST, or with 2 to 3% being spent by the highly developed countries. However, R&D expenditure has grown from a level of 0.23% in 1958-59 to 0.63% in 1978-79; the number of science and technology institutions in the main agencies, ministries and departments of the Central and State Governments, and in the private sector, is about 900, the stock of scientific and technical manpower is around 19 lakhs (see Annexure - III). India today has the third largest complement of S&T manpower, and the S&T base in the country has enabled us to build to a large and varied industrial infrastructure.

With the massive building up of S&T organization system over the period of last 30 years and the experience in S&T Planning, we have learnt some important lessons. We have realised that there is a great need for indigenous capability building and we have to be careful in inputs from

outside the country and ensure that they are appropriate to the socio-economic conditions in the country. We have also realised that there is a great need for ensuring a coordinated effort among the universities, research laboratories and industries and the Government departments/ministries. It was only after 1971 that we realised the importance of systematic S&T planning as an integral part of the socio-economic planning. Earlier S&T inputs were more on an individual basis and were just put together. Now the need has been felt to define an overall national perspective and assign priorities to guide the S&T effort appropriately. Where tasks were well defined and resources allocated, our scientists and technologists have been able to deliver the goods - as in areas such as Atomic Energy, Space, Agriculture, etc. We have, therefore, now to adopt specific goal oriented strategies in important critical areas of the economy such as, steel and mines, drugs, fertilizers new energy sources, ocean science and technology, machine tools, heavy engineering, aircraft industry, etc.

The success of S&T policy and planning process largely depends upon an efficient system of collection and dissemination of information. Though plans for implementation of a National Information System for S&T (NISSAT) and National Informatics Centre (NIC) have been initiated and considerable work has already been carried out in this area, there is still an urgent need to evolve an integrated institutional framework for collecting national and international S&T information, which is a prerequisite to growth of S&T.

While we can be rightly proud of our accomplishments in S&T since 1958, on the other hand our record shows that the implementation of our S&T plans cannot be considered as a total success considering the lack of speed and efficiency with which we have gone about. The implementation process makes heavy demands on the machinery of Government which we have not yet succeeded in mobilizing in a bold way. Whether it is due to lack of scientific temper in the masses, a genuine resistance to change, inability of the economic sectors and the scientific agencies to be linked in a cohesive fashion, or merely because of the bureaucratic approach being taken to apply S&T to economic development is something which must be analysed and rectified if we have to implement efficiently and boldly what we plan so carefully and meticulously. In this context it is relevant to quote again the afterword of the NCST approach document.

> "The task of implementing the Science and Technology Plan will make heavy demands upon the machinery of Government. But, however heavy the demand and however great the challenge, all of us must resolve to meet it; for, we can formulate and we can project; we can envisage and we can programme; we can define and we can

budget; but if we cannot implement with speed and efficiency, we would have failed a new generation and forfeited our mandate to plan".

VI. ACHIEVEMENTS AND FUTURE PROSPECTS THROUGH SCIENCE AND TECHNOLOGY POLICY FORMULATION

Through the adoption of the national Scientific Policy Resolution (SPR) in 1958, the Government, very eloquently, enunciated its commitments to science and at the same time expressed its high expectations from it by stating one of the main objective of SPR as "to secure for the people of the country all the benefits that can accrue from acquisition and application of scientific knowledge".

We cannot claim that this main objective of the SPR is fully achieved. Advances in science and technology are taking place at such a rapid pace that to accrue all benefits from this scientific knowledge would need an equally rapid growth in the science and technology infrastructure in the country; for a developing country this would mean a fast rate of growth of the economy to enable increasing amount of resources to be channeled for the enhancement of the science and technology infrastructure. This has not been possible. Nevertheless, our achievements have been significant and if appropriate organisation changes are brought about in the science and technology planning and implementing process, coupled with commitment to utilization of indigenous R&D in the various sectors of our economy, it may be possible to achieve much more even with the kind of resources which the country can afford. We have to remember that though our financial resources may be meagre, our manpower resource is indeed very strong and we must make best use of it through innovative and bold strategies of implementing our well drawn out science and technology plans. India's experience in planning and implementation is well illustrated by the follow ing statement from a national document.

> "The Indian science and technology system has shown technological capability of a high order, in the sense that whenever it has been entrusted with a clear-cut mission, and backed up with the requisite facilities and funds, it has invariably accomplished its mission. Where the user has not been receptive, or has not cooperated, the science and technology system has faltered".

(a) *Overall Growth through Application of Science and Technology*

Table-3 shows some of the basic indicators of growth which, are, to a considerable extent, influenced by science and technology efforts in the

TABLE - 3

"Some Indicators of National Development during the period 1950 to 1978"

Sl. No.	Indicator	Unit	1950-51	1977-78
1.	Population	Million	358	623
2.	Birth rate	Per annum per thousand population	39.9	34.5
3.	Death rate	-do-	27.4	14.5 (1974)
4.	Life expectancy at birth	Years	32.0	53.2 (1974)
5.	Literacy rate	% of population	16.7	29.5
6.	Real national income			
	a) aggregate	1948-49=100	102.3	260.7
	b) per capita	-do-	99.2	144.8
7.	Gross national product (GNP)			
	a) aggregate	Rs. million	95,030	800.000
	b) per capita	Rupees	266	1,285
8.	Agricultural Production	Triennium ending 1961-62=100	68.9	148.9
9.	Industrial production	1960=100	49.1	250.0
10.	Electricity	Million Kwh.	5,107	98,500
11.	Towns and villages electrified	Number	23,980	207,346
12.	Net area irrigated	Million hectares	20.9	32.6 (1973-74)
13.	Scientific and Technological personnel	Thousands	188	2,328
14.	Universities	Number	27	105
15.	S&T expenditure	Rs. million	289 (1958-59)	4,500 (1976-77)

Source: Centre for Monitoring Indian Economy
Central Statistical Organisation
Department of Science and Technology.

country. These significant changes characterizing the period little after independence have been based upon (a) a massive investment in basic industries; (b) the establishment of wide variety of consumer goods industries; (c) a drive for the modernization of agriculture; (d) strengthening of the infrastructure of power, transport, communication, etc; and (e) an effort to provide social services (education, health, etc.) to increasing numbers.

As has been mentioned earlier, whenever tasks were well defined and resources allocated, the mission has been achieved. This has been particularly so in the areas of atomic energy, space, agriculture, etc. In undertaking such challenging tasks India has clearly demonstrated its determination to use science and technology for peaceful purposes and for the socio-economic benefit of its society and its achievements have certainly been noteworthy.

If we take these achievements and successes as indicators of our capability and faith in the concept of self-reliance through science and technology, there is no reason why we cannot embark on a goal-oriented approach to science and technology as part of the science and technology policy, with specific strategies and targets, converted into science and technology tasks in other economic sectors such as drugs, fertilizers, off-shore engineering, petrochemical, heavy electricals, communications, machine tools, heavy engineering, aircraft industry, housing, etc.

In view of the fact that advances in science and technology are taking place at a very rapid pace, and further, since the utilization of new discoveries and inventions involves a certain amount of lead time, it is necessary that national plans and policies for nurturing science and technology should take an approach for science and technology planning which would involve a plan not restricted to the normal five year socio-economic plan but should extend to atleast a decade or more. In this context, specific efforts will have to be made in identifying and appropriately supporting those areas of science which are in the front-line and have potential for resulting in major breakthroughs. Just to illustrate a few of these areas, one can mention the major advances that are likely to take place in the decade of 1980s in the area of Biological Sciences. Not only are these important areas of fundamental science but the potential through its applications (such as genetic engineering) have already appeared on the horizen and it will be necessary that a long-term policy for the development and growth of biological science has to be planned for the coming decade. In the area of Energy, in view of constraints on non-renewable sources such as oil, coal etc. it is necessary to have a long-term energy policy wherein the role of specific technologies associated with new energy sources has to be identified and appropriate programmes drawn out for the coming decade. In the area of Health, the problem of population control which has always been

the most serious problem, and will continue to remain so, particularly, with developing countries like India. It is therefore necessary to envisage a science and technology policy which will make full use of the various techniques already available for population control and the new technologies of developing appropriate vaccines have to be planned in the national context. Only if one has long-term policies can be one make full use of the potentials which exist in the new developments of science and technology. Simultaneously, one will have to plan for the creation of necessary science and technology infrastructure while adequate administrative machinery has also to be introduced so that the benefits which are realised in the laboratories today are utilised in the field within the time span of a decade.

To conclude, though our achievements in science and technology are creditable inspite of the limited financial resources utilized so far, it is evident that the overall national capability in science and technology is far from being effectively utilized, and while we continue to pursue the ever growing challenges of science and technology, simultaneously there is an urgent need to critically examine and remove the bottlenecks which are present in the effective implementation of our overall science and technology policies and plans. Approrpirate policy instruments have to be urgently implemented if the aspirations of our Scientific Policy Resolution have to be fulfilled. Appropriate long-term plans over the next decade or two have to be drawn out if we have to achieve greater success in bringing about national development through the application of science and technology. The science and technology community is not lagging behind but the juggernaut of Governmental Administrative machinery cannot be pulled by them, and their efforts have to be supported by adequate mechanisms for utilisation of their efforts. It must be remembered that our S&T capability will continue to grow if it is expended or used effectively, otherwise there is a danger of its decay if it remains unused.

VII. NATIONAL SCIENCE AND TECHNOLOGY POLICY IN THE GLOBAL CONTEXT

Over the years, it has been increasingly realised all over the world that science and technology have a major role to play in development of society. As science advanced independently through the efforts of individuals and through their creative ability, the technology that was produced as spin off these activities repeatedly proved to be useful in providing goods and services to mankind. However, it has become clear that if science and technology has to play this useful role, it will be necessary to have an organised and planned approach towards its utilisation. In other words, a need

was felt for the for the formulation of a science and technology policy for individual societies in different countries. Since the social, economic and political conditions which exist in different countries are obviously different, and further since the extent to which S&T infrastructures exist in various countries are different, it was obvious that science and technology policy could not be universal concept in its detail. This becomes particularly important for societies which are economically widely apart, namely, those in the developed and the developing countries.

(a) *International Studies on Science Policy*

At the United Nations level, a major programme of UNESCO, concerned with collecting, analysing and disseminating information concerning the organisation of scientific research in various countries and the policies of those countires towards utilisation of science and technology, was initiated as early as in 1960. These studies covered planning of science policy, organisation and administration of scientific and technological research and other questions relating to formulating and implementation of science policy. While these UNESCO studies were extremely useful, unfortunately they were not very influential in individual governments taking active steps for implementing the science policies. The difficulties involved in implementing a science policy were analysed in an international study supported by the International Development Research Centre (IDRC) in Canada. It designed a programme entitled the "Science and Technology Policy Instruments (STPI)" involving research projects designed to answer some of the questions as to what developing country governments have to do to ensure that their technology and industrialisation policies are consistent with national development objectives. The study also considered ways and means which would be available for implementing such policies. The STPI programme involved a 3½ years study undertaken in 10 developing countries and in addition to the initiative taken by IDRC, it was also sponsored by the Department of Scientific Affairs of the Organisation of American States, national government agencies and academic institutions.

The STPI study took into account the fact that technological considerations were being re-introduced into the economic theory which had neglected them in the recent decades. A new interest in science and technology policy had emerged, highlighted by the contest between East and West for technological leadership in defence. People began to recognise that during the last 150 years, science based technology has nurtured Western industry and that the difference in dynamism between European and American industries have been based on advances in technology. In developed countries, the market economics have competed on the basis of

technological achievement in industries and countries with the planned economies have pursued technology as a means of improving the use of productive resources. In the midst of this, the developing countries have only recently started acquiring, on the one hand, an artisan, technical and engineering base on the other, the capacity to compete in modern science. It is clear that the developing countries had lagged behind in the process of application of science and technology to development which is now in full stream in the developed countries. Hence, it becomes important that the process of industrialisation is accelerated in developing countries and at the same time, it is done in a manner that it activates the development of an endogenous scientific and technological base for industry in the developing countries. This was indeed soon realised by many developing countries (e.g. in India where policies and government measures were successful in creating an infrastructure for science and technology, the link with industrial production was very weak indeed). Faced with a lack of demand for their services, the research institutes, universities and supporting organisations developed a logic of their own, paid lip service to the relevant character of their activities and demanded an ever increasing share of government allocations to finance their expansion. This raised the problem associated with the abuses of technology suppliers from the industrialised world, the transnational corporations in particular. There emerged a movement that blamed the lack of demand for local science and technology on the indiscriminate import of foreign technology. The corresponding measures taken to solve these problems were to regulate imports, and institutions were created to control the abuses of imported technology. The observations celarly embarked the need for a self-reliant development amongst the developing countries. As a result of these critical studies of STPI, the early 1970s focussed on the need to understand more completely the nature of science and technology policy formulation and implementation processes and to relate them specifically to undertake development and the characteristics of different industrial branches.

(b) *The Major elements of S&T Policy - the United Nations Conference on Science and Technology for Development (UNCSTD)*

It is at this juncture when the world was concerned with the proper use of science and technology for development that the United Nations Conference on Science and Technology for Development (UNCSTD) was held in Vienna during August 1979. At this conference, the scope and dimension of science and technology were considered as very major elements in strengthening the S&T capacities of the developing countries. The conference observed that this situation has particularly become serious because the developed coun-

tires are continuing to dominate the field of science and technology to the extent that around 95% of all R&D is being carried out by them while the developing countries, which represent 70% of the population of the world, have only 5% of the world R&D capacity. The recommendations of the conference at national, sub-regional, regional, inter-regional and international levels, give great emphasis to the question of formulation of science and technology policy. It has been recommended that governments of developing countries should formulate a national policy for science and technology which would involve carrying out certain essential responsibilities such as planning, budgeting, management, coordination, stimulation, promotion and execution of scientific and technological activities relevant to defined development objectives of the country. It also implied the bringing out of careful interaction between facts responsible for growth and transformation.

Identifying some of the major elements of S&T policy for developing countries, the conference has recommended as follows:

1. The science and technology components should be included in national development plans or strategies as basic instruments for achieving the different objectives and goals contained in them; these plans should also include specific requirements at the sectoral and intersectoral levels for the generation, mastery, transfer, acquisition, local dissemination, assimilation and utilisation of science and technology, including know-how.

2. An effective science and technology policy should embrace elements such as:

(a) Formulation of science and technology plans with a view specifically to establishing targets for each science and technology sector, determining sectoral priorities arising from national development objective and critically evaluating the resources which may be required as a result of cooordinated intersectoral programmes;

(b) Survey of the state-of-art in each science and technology sector and assessment of the availability of national resources and science and technology potential;

(c) Mobilization of financial resources for scientific and technological development;

(d) Setting up of the appropriate legal, administrative, fiscal and institutional machinery required to carry out the process of

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scientific and technological development; further-more, the science and technology policy should take into consideration manpower, investment and income-distribution policies and be in harmony with the short-term needs as well as long-term requirements;

(e) Development of managerial capacities in research and development and technology in all its facets;

(f) Establishment of a national capacity for assessment, selection, acquisition and adaptation of foreign technology and expertise taking fully into account prevailing economic, social, cultural and environmental consideration;

(g) Stimulation of demand for indigenous research technology and other science and technology services in general;

(h) Diffusion of science and technology among all sectors of the economy, their corresponding programme, and their continued review, appraisal and adjustment at the macro and micro level;

(i) Undertaking of joint projects among all agents of science and technology development;

(j) Promotion of communication and cooperation among Government agencies, research institutions, professional societies and technology users;

(k) Education and training of the human resources required to generate and implement science and technology development policies, plans, programmes and projects;

(l) Promotion of basic and applied research, and research and development in a balanced mix;

(m) Protection of the traditional scientific and technological base and, at the same time, upgrading of such knowledge in order to utilize it fully in the development process; and

(n) Ensuring that the earning capacity of rural population is increased through the application of science and technology.

It will thus be seen that all over the world it is being increasingly accepted that a coherent science and technology policy is vital for progress. The formulation of science and technology policy for development is indeed a global phenomenon. But obviously the impact of a well drawn out policy can be measured only through the success achieved in its imple-

mentation. Considering the problems involved in implementation, which are very specific to individual societies, it must be realised that there cannot be a global approach to the implementation of such a policy for science and technology; individual countries have to evolve their own mechanisms for formulation and implementation of the science and technology policy programme.

India, while taking note of these global studies has precisely undertaken an approach of its own and having enuciated its Scientific Policy Resolution in 1958, we are still on the long journey of ensuring that our objectives stated in the policy are implemented and realised in the near future. The problem formulation stage is perhaps now over and the more difficult part of finding the solutions is where the developing countries are groping for the necessary willpower and courage.

VIII. CONCLUDING REMARKS

In a paper of this nature, it is somewhat difficult to arrive at definite conclusions. The paper has tried to highlight the developments in science and technology in the pre-independent and post-independent India; building up of S&T infrastructure in the country; experiences in integrated S&T planning; and achievements made through S&T efforts. India's appraoch to S&T development is compared with the global context of science policy formulation for developing countries. To summarize the discussions in the paper, the following are some of the important features, which deserve mention.

(i) In India, development of S&T had taken place even before it attained independence and these developments have played a very significant role in the building up of S&T infrastructure in Post-Independent India.

(ii) The S&T system has got a very direct relationship with the education and the training sector. Manpower planning has to be based on the demands of the S&T system and the appropriate utilization of the generated manpower.

(iii) There is need to establish closer linkages between the R&D institution, Industry Sector, and the Education/University Sector from the viewpoint of transfer of technology from laboratory to the field. The consulting organisations, Engg. bodies/professional bodies should also be involved in this process in order to provide a total package for any S&T development i.e. to provide a technology delivery system and extension service.

(iv) Though certain mechanisms have been evolved to prepare national S&T Plans and their integration with the socio-economic Plans, there is still a need to strengthen this process, particularly the implementation and follow-up machinery.

(v) There is a need to look into the non-uniformity and uneveness in the growth of some S&T areas (Table 1), where already there have been large inputs and some other areas which received negligibly smaller inputs. Some efforts have been made to correct these imbalances.

(vi) The Indian S&T system has shown technological capability of a high order, in the sense that whenever it has been entrusted with a clear-cut mission, and backed up with requisite facilities and funds, it has invariably accomplished its mission.

(vii) The S&T system in India, is presently devoting attention to the above features, but the efforts are uneven. The basic problem is much more with the thrust of the S&T system than with its size; with the direction of its technological capability than with creation/strengthening of this capability; with optimum allocation of S&T resources than with its magnitude.

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GOVERNMENT OF INDIA
SCIENTIFIC POLICY RESOLUTION

New Delhi, the 4th March, 1958.

No.131/CF/57. The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications.

2. The dominating feature of the contemporary world is the intense cultivation of science on a large scale, and its application to meet a country's requirements. It is this, which, for the first time in man's history, has given to the common man in countries advanced in science, a standard of living and social and cultural amenities, which were once confined to a very small previledged minority of the population. Science has lead to the growth and diffusion of culture to an extend never possible before. It has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and give to civilization a new vitality and a new dynamism.

3. It is only through the scientific approach and method and the use of scientific knowledge that reasonable material and cultural amenities and services can be provided for every member of the community, and it is out of a recognition of this possibility that the idea of a welfare state has grown. It is characteristic of the present world that the progress towards the practical realisation of a welfare state differs widely from country to country in direct relation to the extent of industrialisation and the effort and resources applied in the pursuit of science.

4. The wealth and prosperity of a nation depend on the effective utilisation of its human and material resources through industrialisation. The use of human material for industrialization demands its education in science and training technical skills. Industry opens up possibility of greater fulfilment for the individual. India's enormous resources of manpower can only became an asset in the modern world when trained and educated.

5. Science and technology can make up for deficiencies in raw materials by providing substitutes, or, indeed, by providing skills which can be exported in return for raw materials. In industrialising a country, a heavy price has to be paid in importing science and technology in the form of plant and machinery, highly paid personnel and technical consultants. An early and large scale development of science and technology in the country could therefore greatly reduced the drain on capital during the early and critical stages of industrialisation.

6. Science has developed at an ever-increasing pace since the beginning of the century, so that the gap between the advanced and backward countries has widened more and more. It is only by adopting the most vigorous measures and by putting forward our utmost effort into the development of science that we can bridge the gap. It is an inherent obligation of a great country like India with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today.

7. The Government of India have accordingly decided that the aims of their scientific policy will be:

i) to foster, promote and, sustain, by all appropriate means, the cultivation of sciences, and scientific research in all its aspects - pure, applied and educational;

ii) to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognise their work as an important component of the strength of the nation;

iii) to encourage and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfil the country's needs in science and education, agriculture and industry, and defence;

iv) to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;

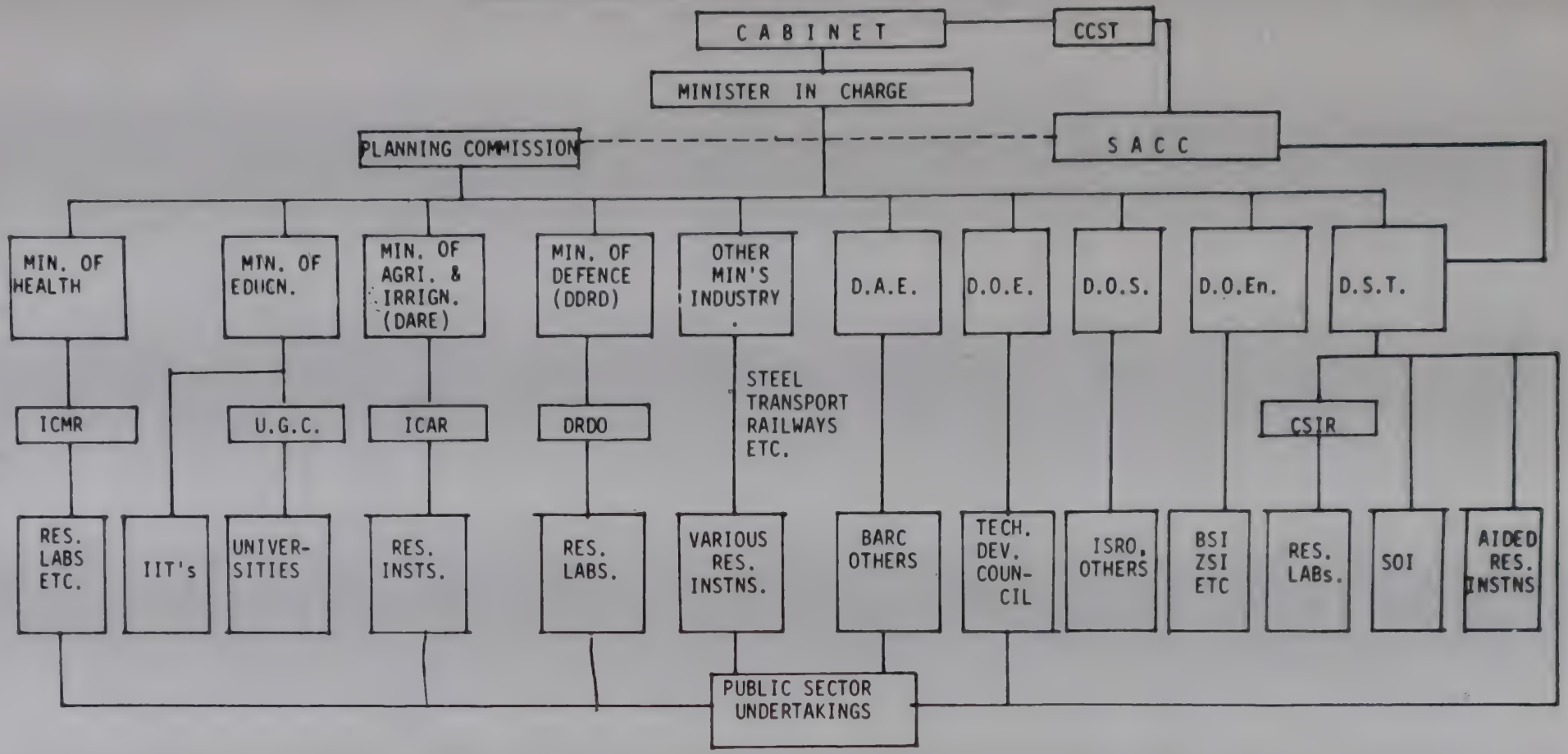
v) to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom; and

vi) in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The Government of India have decided to pursue and accomplish these aims by offering good conditions of service to scientists and according them an honoured position, by associating scientists with the formulation of policies, and by taking such other measures as may be deemed necessary from time to time.

ANNEXURE II

ORGANISATIONAL CHART OF SCIENCE AND TECHNOLOGY, INDIA



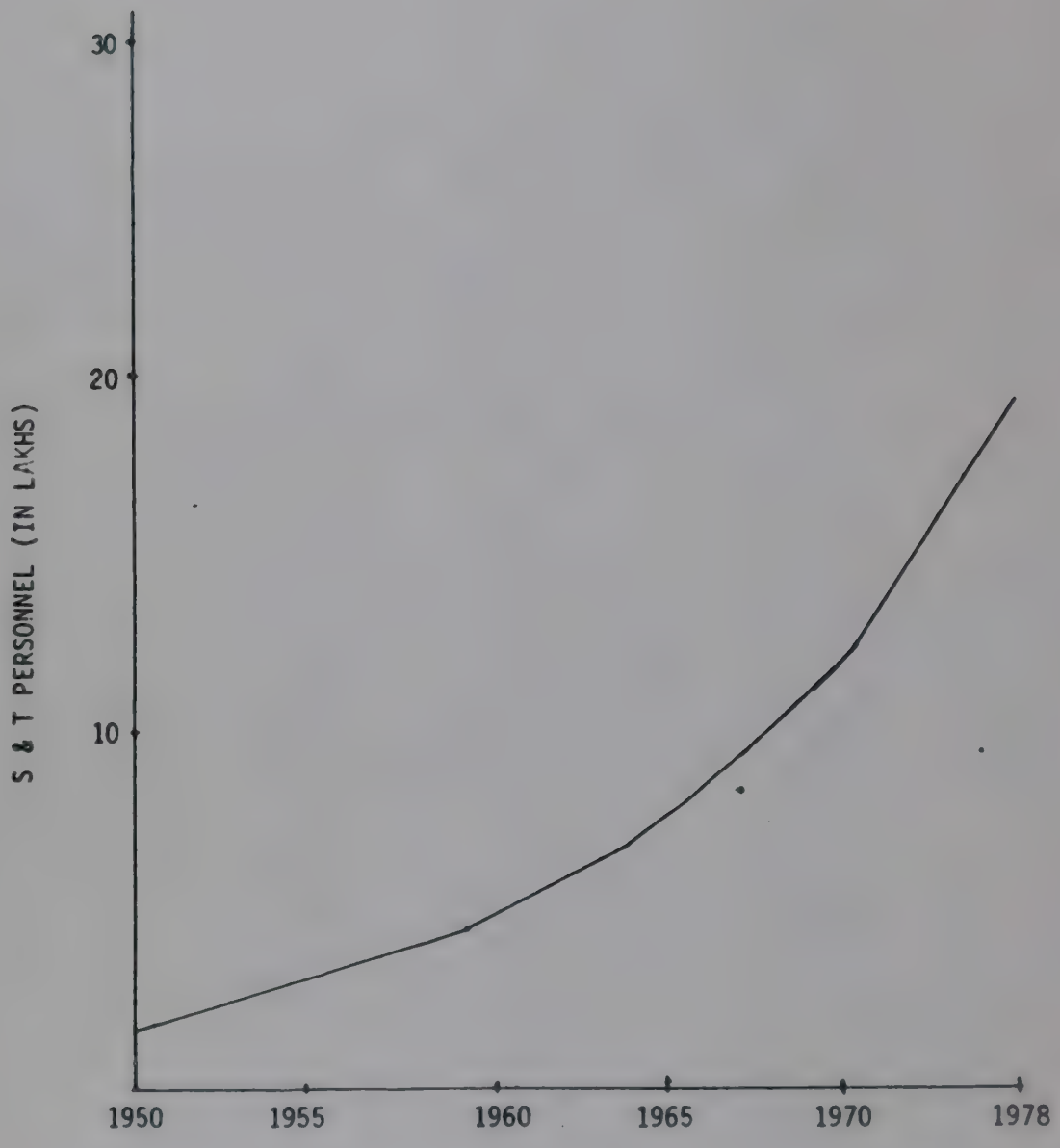
DAE - Dept. of Atomic Energy
DOE - Dept. of Electronics
DOS - Dept. of Space
DOEn - Dept. of Environment
DARE - Dept. of Agricultural Research and Education
DDRD - Dept. of Defence Research and Development
CCST - Cabinet Committee on Science and Technology

NOTE:

SACC - Science Advisory Committee to the Cabinet
DST - Dept. of Science & Technology
ICMR - Indian Council of Medical Research
UGC - University Grants Commission
ICAR - Indian Council of Agricultural Research
DRDO - Defence Research Development Organisations

ISRO - Indian Space Research Organisation
BSI - Botanical Survey of India
ZSI - Zoological Survey of India
CSIR - Council of Scientific and Industrial Research
BARC - Bhabha Atomic Research Centre
SOI - Survey of India

GROWTH OF S & T PERSONNEL



ANNEXURE IV

FIVE YEAR PLAN - 1978-83 S&T OUTLAYS

(Rs. in Crores)

Sl. No.	Agency/Deptt./Min.	Fifth Plan 1974-79 (Plan outlay)	Plan 1978-83 (Plan outlay)	Non-Plan 1978-83 (Outlay)
1	2	3	4	5
	A. S&T Agencies			
1.	Atomic Energy (R&D)	167.13	220.00	210.00
2.	Space	128.27	210.00	116.00
3.	D.S.T.	58.96	110.00	145.00
4.	C.S.I.R.	81.77	110.00	162.00
5.	National Test House (Supply)	2.10	4.48	3.50
	TOTAL A	438.23	654.48	636.50
	B. S&T Component under Ministries/Departments			
6.	Heavy Industry	28.76	49.91	60.00
7.	Industrial Development	10.74	20.25*	10.00
8.	Steel	6.62	32.78	1.00
9.	Mines	6.48	18.00	---
10.	Power	8.69	20.00	4.10
11.	Coal	6.39	18.00	13.28
12.	Petroleum	12.08	31.98	17.61
13.	Chemicals and Fertilisers	2.35	16.00	3.50
14.	Electronics	18.73	30.00	5.00
15.	Communications	22.39	34.11	24.21
16.	Information and Broadcasting	0.77	2.00	1.50
17.	Shipping and Transport	2.98	23.74@	3.48
18.	TCA-IMD and Institutues	19.58	50.00	60.00
19.	R&D DTE. C.A.	0.38	1.00	0.80
20.	Works and Housing	0.53	1.50	3.60
21.	Labour	0.15	0.50	---
22.	Education	35.50	30.00 ***	16.00 *
23.	Social Welfare	---	2.52	---

1	2	3	4	5
24.	Health ICMR	21.32	12.00	21.44
25.	Rural Reconstruction	1.21	5.50	---
26.	Agricultural ICAR**	153.56	300.00	155.00
27.	FRI	4.70	11.10	---
28.	Food	3.20	5.70	2.50
29.	Irrigation	8.48	5.41	---
30.	Railways(RDSO)	---	---	30.00
	TOTAL B	375.59	721.95	433.02
	GRAND TOTAL	813.82	1376.43	1069.52

* Tentative

** Including Education and Training

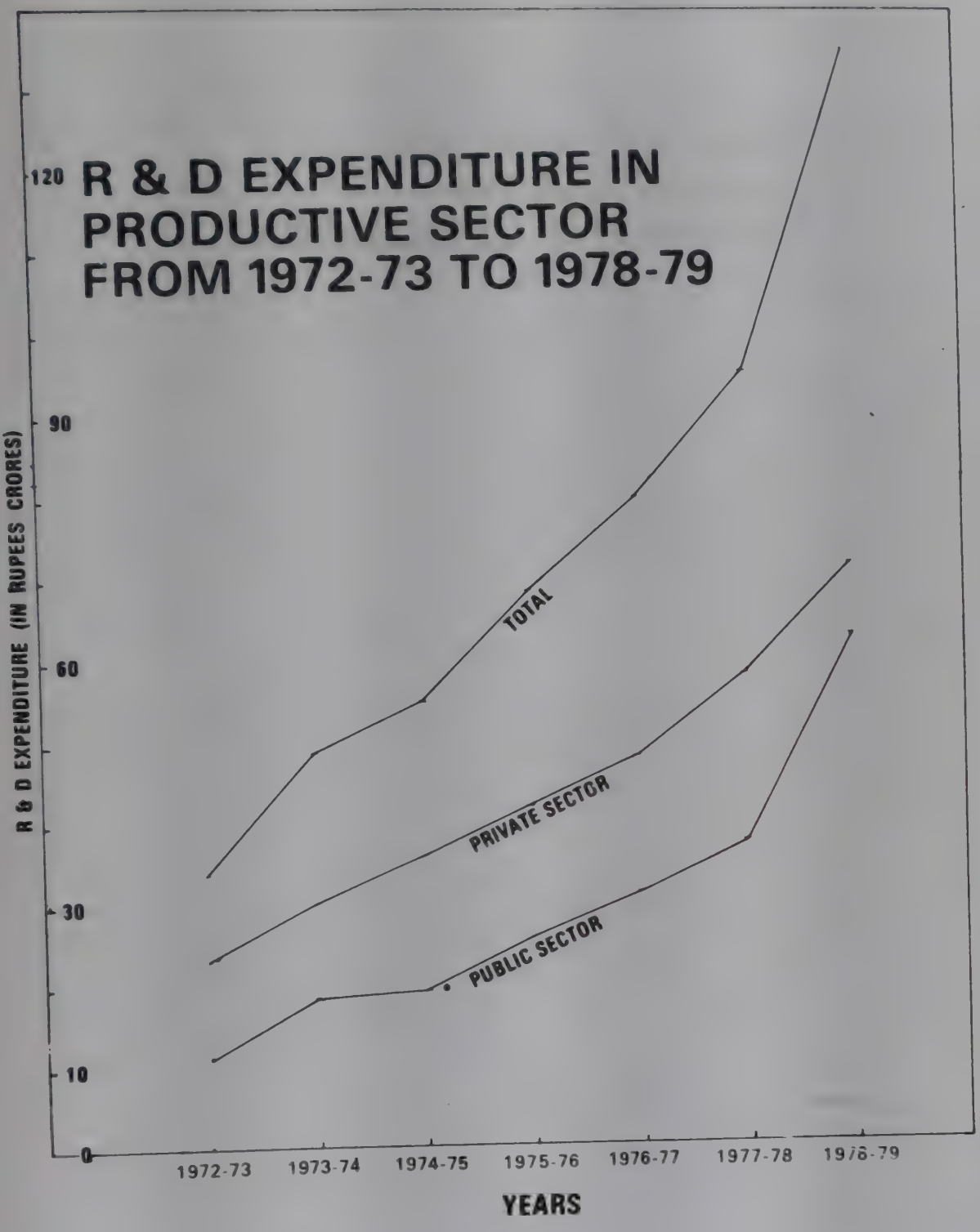
*** Estimated provision for grants-in-aid to Universities by UGC. Does not include RDD in IIT. @ Includes Rs.12.14 crores for ship-building industry.

Note:

(i) Includes plan outlays for operational programmes of Survey of India, NRDC and IMD, grant-in-aid by ICAR to Agriculture Universities, Excludes outlay for research in rubber, coffee, sericulture, etc.

(ii) The non-plan outlays include estimated recurring expenditure to be met from internal resources of public sector undertakings.

ANNEXURE V


R & D EXPENDITURE IN PRODUCTIVE SECTOR FROM 1972-73 TO 1978-79
R & D EXPENDITURE (IN RUPEES CRORES)
120
90
60
30
10
0
TOTAL
PRIVATE SECTOR
PUBLIC SECTOR
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
YEARS

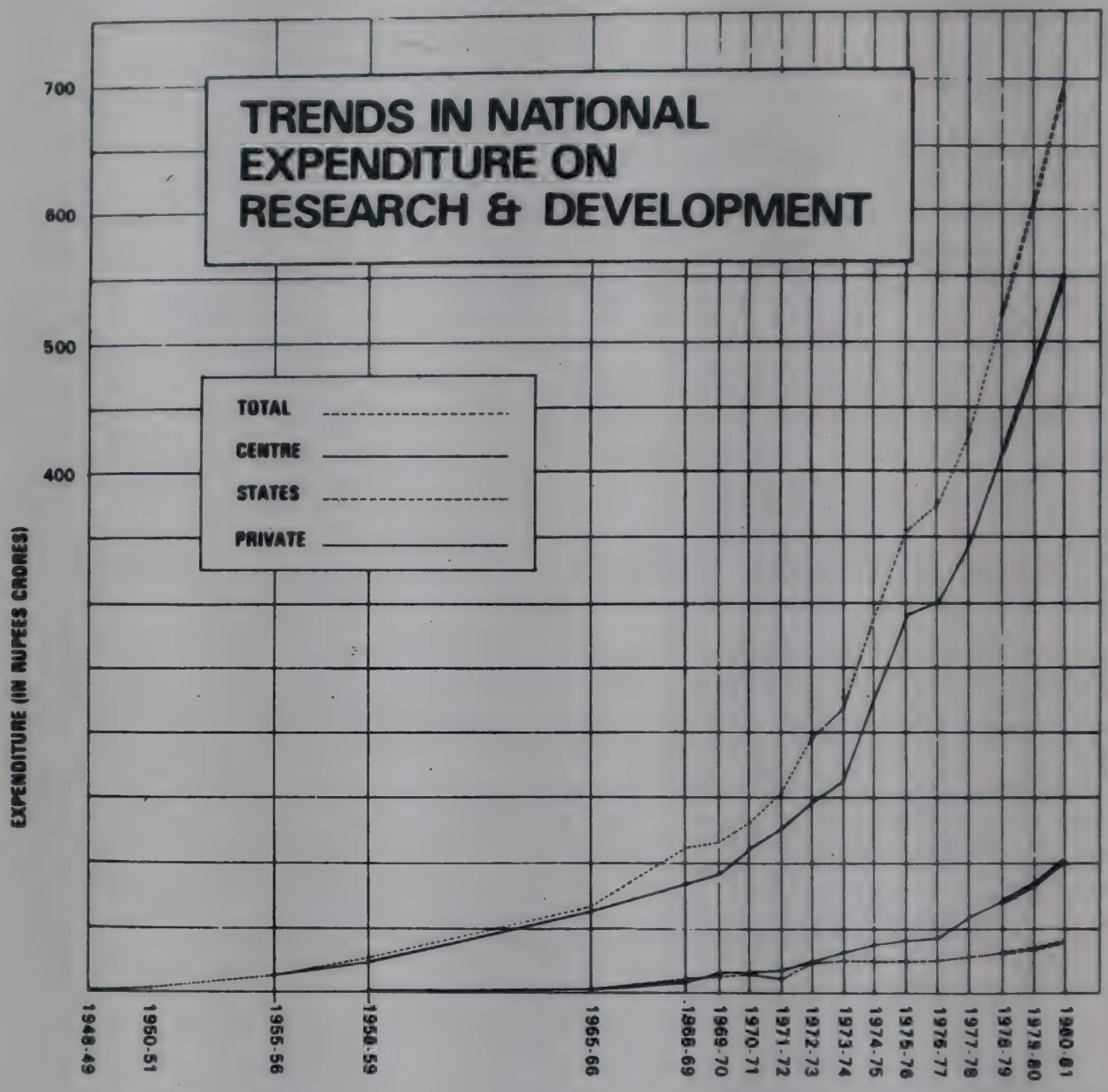

TRENDS IN NATIONAL EXPENDITURE ON RESEARCH & DEVELOPMENT
TOTAL
CENTRE
STATES
PRIVATE
EXPENDITURE (IN RUPEES CRORES)
700
600
500
400
1948-49
1950-51
1955-56
1960-59
1965-66
1968-69
1969-70
1970-71
1971-72
1972-73
1973-74
1974-75
1975-76
1976-77
1977-78
1978-79
1979-80
1980-81

Figure 1

ANNEXURE VII

SIXTH PLAN OUTLAYS SCIENCE AND TECHNOLOGY

(Rs. in crores)

Sl. No.	Agency/Deptt./Ministry	1980-85 (Plan outlay)	1980-85 (Estimated Non-Plan outlay)*
A.	***S&T Sector-Agencies***		
1.	Atomic Energy (R&D)	248.98	248.59
2.	Space (S&T)	245.80	146.92
3.	D.S.T.	134.87	189.55
4.	Environment	40.00	13.12
5.	C.S.I.R.	170.00	218.24
6.	NTH (Supply)	8.50	3.55
	SUB-TOTAL 'A'	848.15	855.98
B.	***Other Sectors - S&T Component under Ministries/Deptts.***		
7.	Heavy Industry	57.51	100.00
8.	Industrial Dev.		
	(i) Large & Medium industries	8.41	10.00
	(ii) Small Scale Industries	9.29	
9.	Commerce		
	(i) Textiles Research Associations	6.50	8.40
	(ii) Other Programmes	25.00	
10.	Steel	41.70	
11.	Mines	16.16	
12.	Power	53.10	5.00
13.	Coal	25.00	15.00
14.	Petroleum -		
	(i) Petroleum	39.08	30.00
	(ii) Petro-Chemicals	5.58	
15.	Chemicals & Fertilizers	26.03	3.50

1	2	3	4
16.	Electronics	32.34	3.00
17.	Communications	62.15	33.00
18.	Information & Broadcasting	2.50	2.00
19.	Shipping and Transport	12.75	5.00
20.	T.C.A. -		
	(i) IMD & Institutes	45.00	73.00
	(ii) R&D Dte., C.A.	1.50	0.80
21.	Works & Housing-CBRI	2.00	3.80
22.	Labour	1.06	
23.	Education	112.00	30.00
24.	Health-ICMR	40.00	26.00
25.	Social Welfare	2.00	
26.	Rural Reconstruction	10.05	
27.	Agriculture -		
	(i) ICAR	340.00	190.00
	(ii) FRI	12.00	
28.	Food	8.10	3.30
29.	Irrigation	20.45	14.00
30.	D.S.T.	54.00 @	
31.	Railways (RDSO)		36.00
	SUB-TOTAL 'B'	1071.26	591.80
	GRAND TOTAL (A+B)	1919.41	1447.78

* Tentative Estimates.

@ Rs.50 crorse under energy Sector and Rs.4 crores under Housing and Urban Development Sector.